



# NextGen Crew Countermeasure Software for Exploration Mission Support

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# Objectives



- ◆ Develop and integrate new instructional, motivational and socialization techniques with improved interfaces with the aim of reducing or preventing bone and muscle deconditioning and improving the overall physical and psychological conditioning and performance of the crew while on-orbit or on other terrestrial surfaces.
- ◆ Specifically, this project proposal will test whether, 1) improving the usability of crew interface software to exercise CMS through common app-like interfaces, 2) introducing instructional motion training, and 3) incorporating socialization through a virtual environment with family and friends, will improve exercise technique, adherence, and performance outcomes.
- ◆ Fundamentally, this is a software architecture design project that will establish the groundwork for standardization of the proposed multi-component, multi-faceted software architecture for all future exploration class exercise equipment.



# Specific Aim 1: Software Usability



**ARED Current Exercise**

Heel Raise

Current Time (day month year hh:mm:ss) 29 Aug 13 23:56:48

Exercise Duration (hh:mm:ss) 00:08:33

Instantaneous Load 0 kg

Detailed Setup Instructions  
Heel Raise: arm high, bar @ 28, pull pins

Set	Rx Reps	Rx Load	Dialed Load	Actual Reps	Average Load	Date
1	10	90.7 kg				
2	10	90.7 kg				
3	10	90.7 kg				
4						
5						
6						
7						
8						

Session 001

Start

ARED Rx <Home> Exercise Log User Guide View Graph <Pg/Up> Change Values to English <Pg/Dn>

**Calculating Thresholds, do a few full repetitions ...**

Threshold Calibration 18 Jan 2017 13:06:38

**Deadlift**

Current Load 0

Repetitions 0 / 10

Sets 0 / 3

Elapsed Time 01:35

Heart Rate 0

Rep Thresholds

Stop Exercise

- ◆ Software interface system to be standardized across the astronaut exercise devices (both aerobic and anaerobic, including an ergometer, treadmill, rower or strength training hardware)
- ◆ Address usability, satisfaction and efficiency with objective metrics and questionnaires contrasting new interface with current interfaces.
- ◆ Minimize astronaut training needs, utilize the latest GUI designs focused on intuitive ease of use approach (80% of the functionality gained within 5-10 minutes of use).
- ◆ Each phase of the usability testing will be conducted with at least 10 participants, the goal is to find design concerns of the user interface.
- ◆ To evaluate the user interface, we will conduct iterative usability testing. The purpose is to find any interface design issues that can cause errors, frustration, and could increase task time.



# Evaluation Tools



- To evaluate the user interface, we will conduct iterative usability testing.
- Testing will consist of asking users to complete high frequency or high criticality tasks related to the system and capture their performance (e.g., error, task time) and subjective comments.
- Errors and task time will be recorded during the testing sessions by the system or the test conductor.
- Subjective comments will also be collected during the usability studies by asking subjects to think aloud while completing the tasks.
- The issues will be ranked based on frequency and severity. The errors and comments will help to identify design problems that can be corrected for the final software interface.

## System Usability Scale (SUS)

Please rate the following items on a 5-point scale, 1 being strongly disagree, and 5 being strongly agree.

1.	I think that I would like to use this system frequently.	1	2	3	4	5
2.	I found the system unnecessarily complex.	1	2	3	4	5
3.	I thought the system was easy to use.	1	2	3	4	5
4.	I think that I would need the support of a technical person to be able to use this system.	1	2	3	4	5
5.	I found the various functions in this system were well integrated.	1	2	3	4	5
6.	I thought there was too much inconsistency in this system.	1	2	3	4	5
7.	I would imagine that most people would learn to use this system quickly.	1	2	3	4	5
8.	I found the system very cumbersome to use.	1	2	3	4	5
9.	I felt very confident using the system.	1	2	3	4	5
10.	I needed to learn a lot of things before I could get going with this system.	1	2	3	4	5

For odd items: subtract one from the user response.

For even-numbered items: subtract the user responses from 5

This scales all values from 0 to 4 (with four being the most positive response).

Add up the converted responses for each user and multiply that total by 2.5. This converts the range of possible values from 0 to 100 instead of from 0 to 40.

Reference: Bangor, A, Kortum, P, Miller, J (2008). An Empirical Evaluation of the System Usability Scale, *Intl. J of Human-Computer Interaction*, 24(6), 574-594.

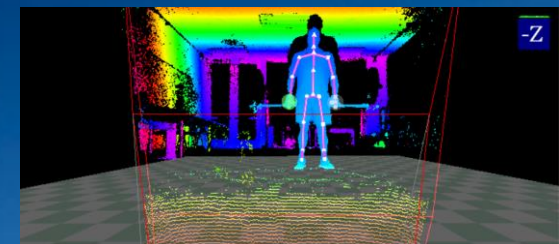




# Specific Aim 2: Virtual Personal Trainer for Long Duration Space Flight



- ◆ Resistance exercise is needed to maintain proper health during space flight but with poor technique, especially in spinal loading exercises, can result in serious injuries
  - **Ex. Rounded back during deadlifts can result in disc herniation**
- ◆ For long duration spaceflight, exercise feedback from ground support may become more challenging due to communication delays.
- ◆ The Kinect can track the 3D position of 26 skeletal joints using an infrared camera which can be used to display, record and instruct the crewmember on repetition consistency in multiple joint movements reducing the incidence of injurious exercise technique.
- ◆ **Objective:** Develop a tool that can provide real-time instruction and correctional feedback for crew members in the absence of real-time ASCR support during exercise to prevent avoidable injuries and optimize overall muscle strength outcomes.
- ◆ **Hypothesis:** Subjects who have access to the instructional software tool with real-time kinematic feedback will perform resistance exercise with more appropriate and consistent technique than those without the instructional software.

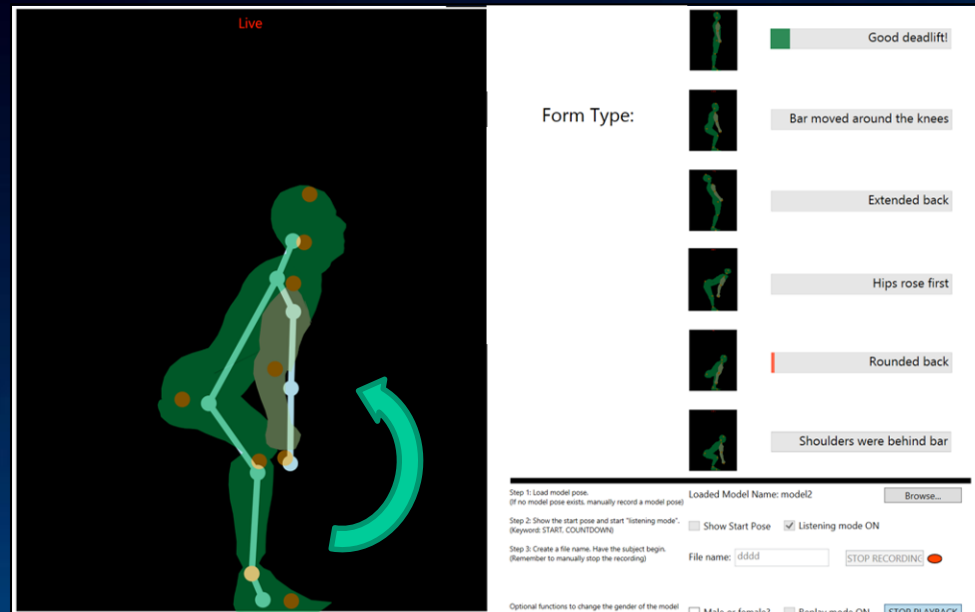




# Exercise Instruction and Feedback Software



- ◆ The software tool uses the Kinect to provide real-time user feedback and corrects any mechanical errors that could result in injury
- ◆ Current features
  - a real-time sagittal view of the joint positions
  - Provides a personalized silhouette for the user to follow during exercise
  - Voice activation
  - Corrective feedback determined by AdaBoost motion learning algorithms
- ◆ Remaining work
  - Refine user interface
  - Expansion of motion learning database
  - Usability and feasibility testing





# Study Design Specific Aim 2

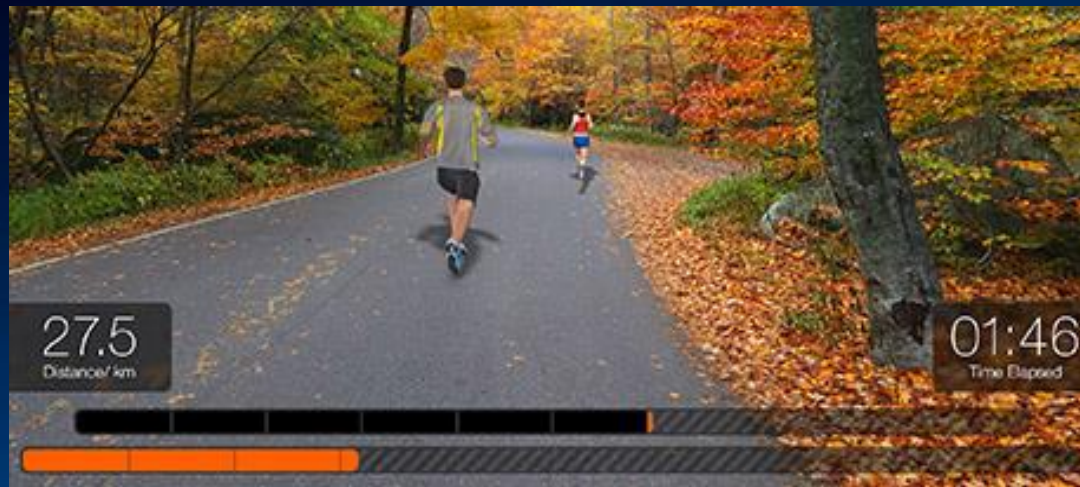




# Specific Aim 3



Specific Aim 3: Test the integration of an existing virtual reality software tool for its effectiveness to improve performance in a single bout of high intensity exercise, and adherence during a one-month metabolic conditioning program.







# Study Design Specific Aim 3



## Hypothesis 3B

Random Order

20 Participants

VO2 Max Test

Timed-Run to-failure  
(with music and  
software)

Timed run-to-failure  
(with music alone)

Timed run-to-failure  
(with nothing)

Hypothesis 3A

Matched Pairs  
Randomized

1-month training  
protocol with software  
and music (n=10)

1-month training  
protocol with music  
alone (n=10)

Vo2 Max Test

Timed run-to-failure  
(with music and  
software)

Timed run-to-failure  
(with music alone)

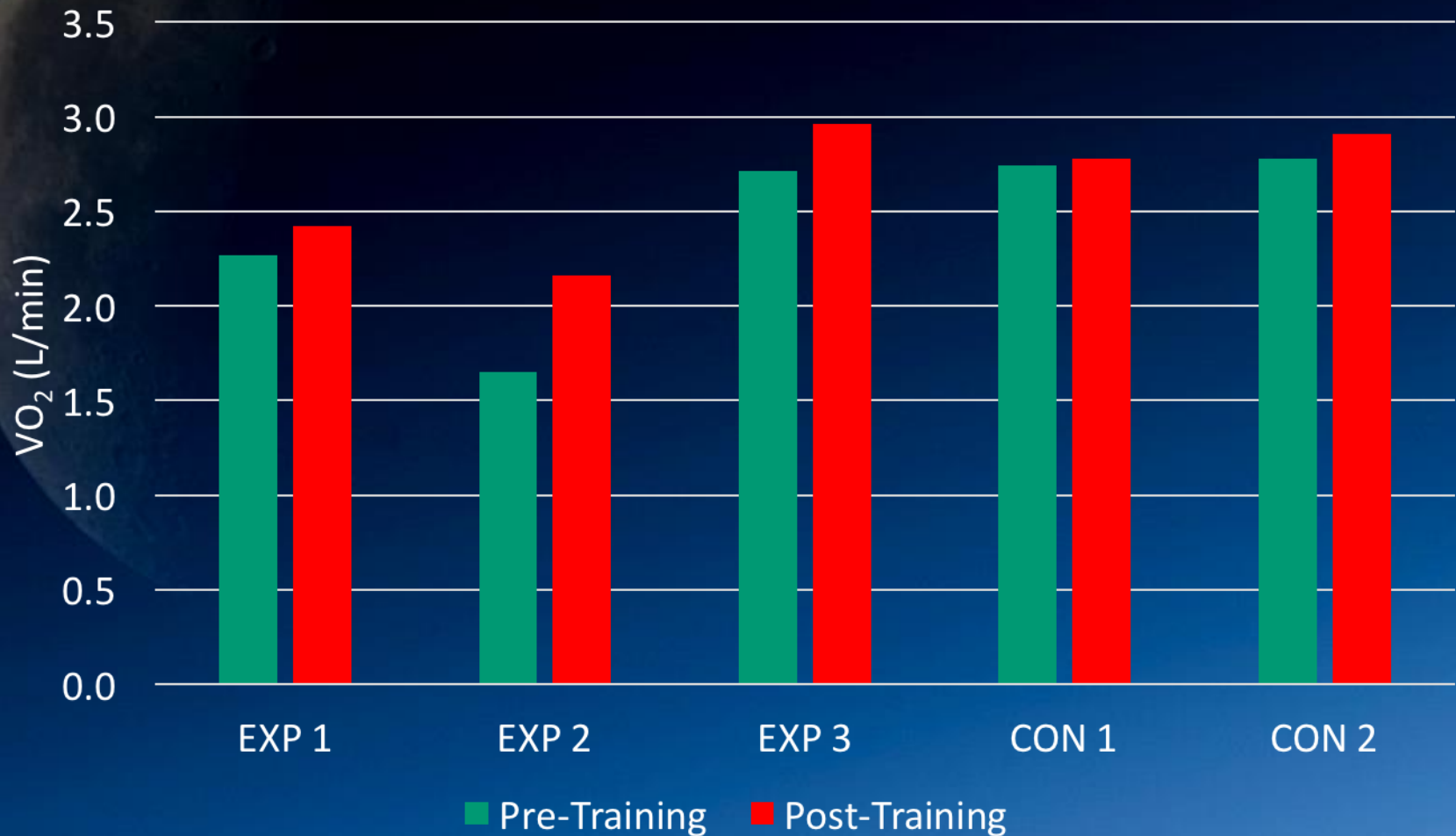
VO2 Max Test

Timed run-to-failure  
(with music alone)

Operational  
Question

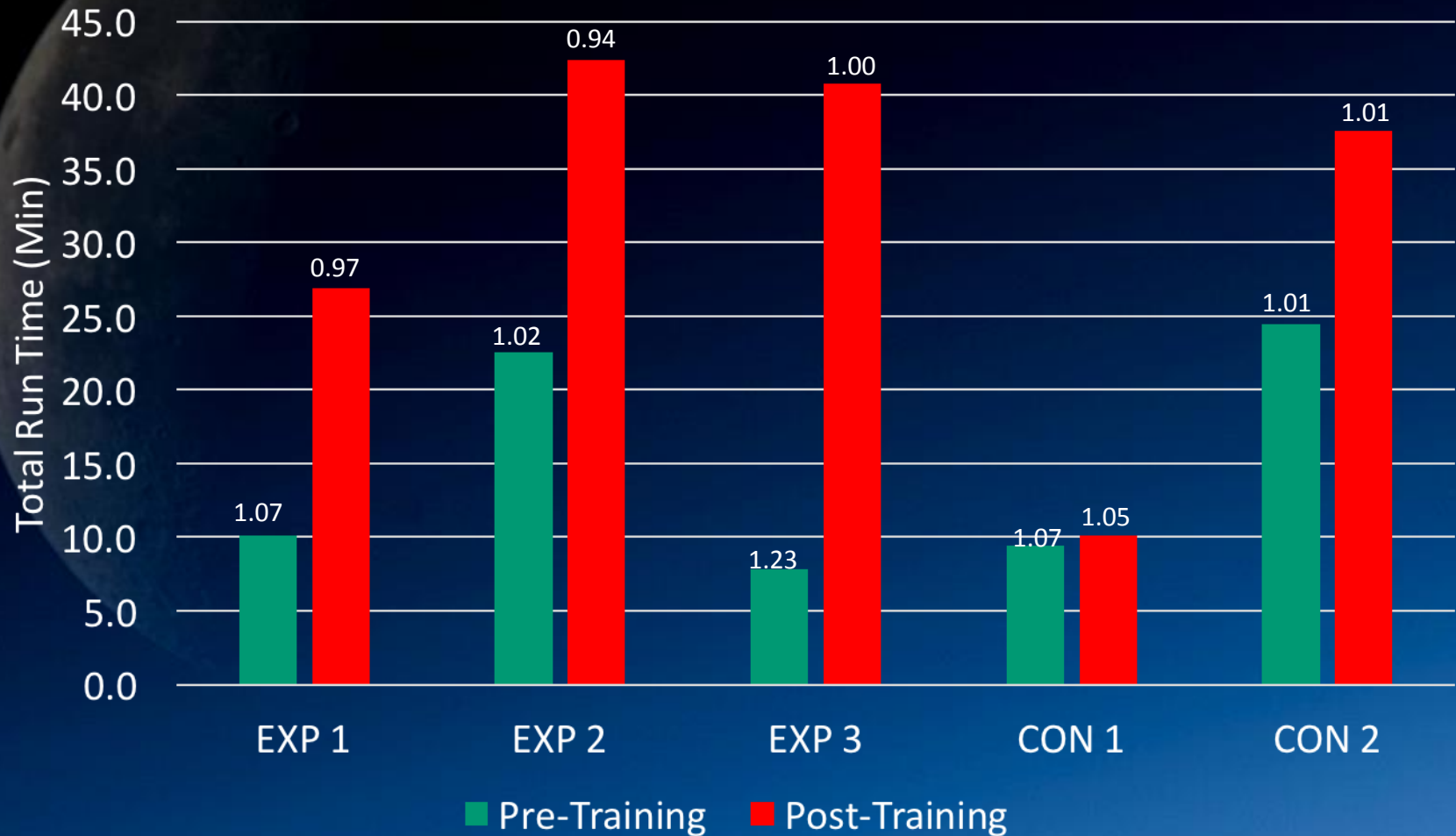


# Changes in $\text{VO}_2$ after 4-weeks of Intense Treadmill Exercise





# Changes in Timed Run-to-Failure after 4-weeks of Intense Treadmill Exercise



\*Note that textbox over bar indicates the peak respiratory exchange ratio for the test. Notice the changes in metabolic efficiency experiences by participants post training.